AGS Complex Machine Studies

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AGS Working Points for AtR , MS I

Study Period:	12 October 1994, 12:45 - 14:30 pm
Participants:	L. Ahrens, K.Brown, E. Gill, W. van Asselt, M. Tanaka
Reported by :	M. Tanaka
Machine:	AGS @ extraction flattop
Beam:	Bunched Au^{77+} beam @ p = 11.23 GeV/c/N
Instruments:	IPM, Tune Meter, CT, Frequency Analyzer, WCM
Aim:	***To explore the optimal working point for AtR transfer.***

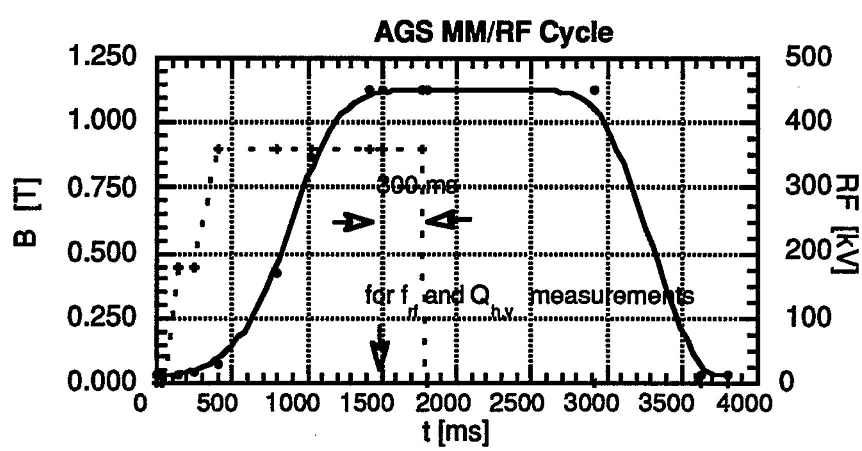
Introduction:

This study is the first attempt to get some real data in order to specify the basic AGS NewFEB operation parameters for AtR beam transfer[1].

Setup and Data Taking:

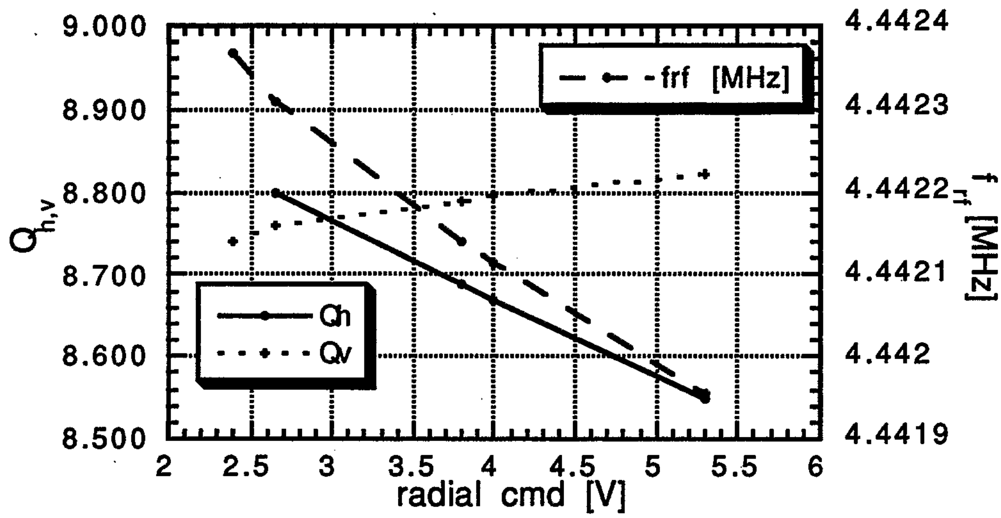
We used the current machine setup for the FY95 HIP/Au^{77+} SEB run except for the following changes:

-the rf turnoff time was delayed 300 ms from 1467 ms to 1767 ms from t_0 and the rf voltage was flattened at 360 kV during this period.
-the SEB flattop in the main magnet cycle was flattened at 1.1250 T.
☞ p = 11.23 GeV/c/N or 28.725 GeV/c/Charge or $B\rho$ = 95. 82 T-m.
-SMF05, SMF10 and DSX's were turned off.



-the local oscilloscope time window was set such that we could monitor the current transformer(CT) reading during the flattop.
-the time of the rf frequency, f_{rf} measurements was set at t = 1500 ms with a 20 ms window.

First, we systematically varied the mean beam radius <dR> by changing the voltage of the radial shifter(RS) and measured f_{rf} and $Q_{h,v}$ at t = 1500 ms for each setting to find out the value corresponding to <dR > = ~0.0 as shown in the following figure.



- the beam was lost at RS = 2.2 and 5.5 V.
- we set RS = 3.8 V for <dR> = ~0.0.
- on the flattop,
  -Au^{77+} intensity = ~$1\cdot10^9$ ions/cycle.
  -tune control quadrupole currents, $IQ_{h,v}$ = {275A, -430A}(on from 1250 - 2920 ms)
  -chromaticity control sextupole currents, $IS_{h,v}$ = {340A, 0A}.
  -skew quadrupole current ISKQ =50 A.

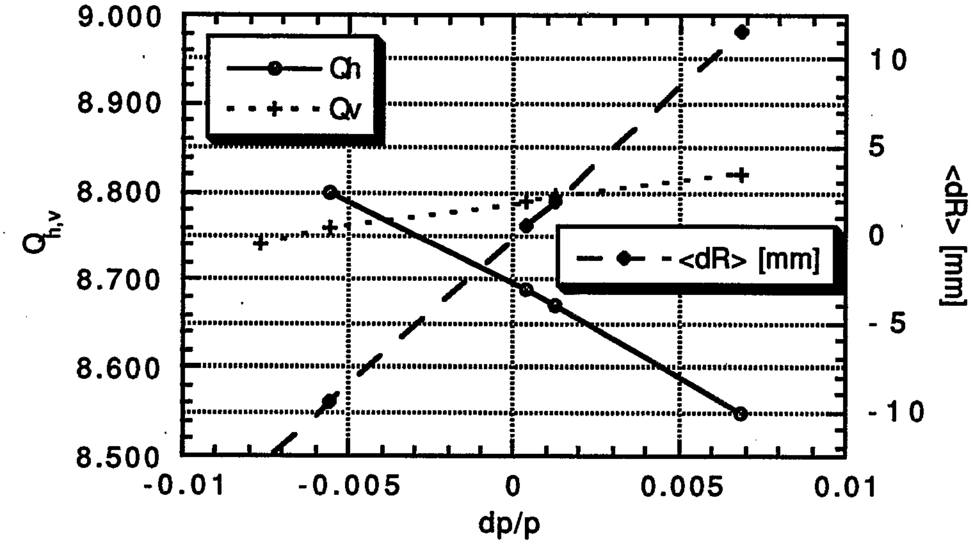
Then, sitting at <dR> = ~0.0 mm, we turned on/off the chromaticity sextupoles, the skew quadrupoles and the tune quadrupoles to see whether there were any changes in beam intensity or in bunch shape.

Results:

•The measured f_{rf} values are converted to dp/p_0 and to <dR> using the formula:

$$\langle dR\rangle = \alpha_p \cdot R_0 \cdot (dp/p_0) \quad \text{and} \quad f_{rf} = h\cdot f_{rev} = hc\cdot(p/E)/(2\pi\cdot(R_0+\langle dR\rangle))$$

where α_p = ~0.0132, R_0=128.452 m, p_0 =11.228 GeV/c/N, h = 12, c = speed of light and $p/E = \beta_{rel}$.
The results are shown in the following figure. For $dp/p_0 = 0$ at <dR> = 0, we should have f_{rf} = 4.442146 MHz which is very close to the measured value f_{rf} = 4.442139 (± 35) MHz at RS = 3.8 V, corresponding to dp/p_0 = 0.00039 or <dR> = 0.66 mm. From the figure, we have $Q_{h,v}$ = {8.69, 8.79} at dp/p =0 and $\xi_{h,v} = dQ_{h,v}/(dp/p)$ = {-20, +4.8}. These values are consistent with the MAD predictions of $Q_{h,v}$ ={8.668, 8.793} and $\xi_{h,v}$ = {-22.6, +7.7} with $IQ_{h,v}$ = {275A, -430A} and $IS_{h,v}$ = {340A, 0A}



•At RS = 3.8V (i.e., <dR> = ~0. 0 mm)

action	**f_{rf} [MHz]**	**{Q_h, Q_v}**	**MAD $Q_{h,v}$, and $\xi_{h,v}$**
- startup point	4.442139 ± 35	{8.69±0.01, 8.79}	{8.668, 8.793} {-22.6, 7.7}
② turned off the chro. sexts	4.442136 ± 37	{8.67, 8.795}	{8.668, 8.793} {-36.0, 15.0}
- turned off the skew quads	4.442134 ± 33	{8.67, 8.795}	-----------------
③ turned off the tune quads	4.442141 ± 51	{8.65, 8.685}	{8.639, 8.677} {-36.0, 16.0}
✍ the beam survived but it appeared very tight.			
④ $IQ_{h,v}$ = {550A, -480A}	4.442143 ± 33	{8.79?, 8.758}	{8.765, 8.763}
⑤ IQh,v =~{475A, -480A}	4.442143	{8.735, 8.775}	{8.736, 8.777}

•Other data during the 300 ms period

a) CT data:
✍ throughout the study, we watched CT readings on the oscilloscope for any beam losses and did not see any significant changes except it appeared that there was a steady decrease in intensity by 3-4 % (~18 % loss over the 1.5 sec flattop).

b) IPM data:
✍ it did not reveal any clear beam losses.
✍ $\varepsilon^*_{h,v}(95\%)$ stayed constant at {10, 7}π mm-mrad.

c) WC M mountain range display:
✍ the bunch shape stayed constant with the full bunch length = ~22 ns.

•Miscellaneous

✍ we turned on/off DSX's and BLWF07 (a bump for SMF05&F10) and saw no effects. However, it turned out that these devices started at t = 1580 ms while f_{rf} and $Q_{h,v}$ measurements were done at t = 1500 ms.
✍ we did not see any changes in the CT reading when we set ξ_h = 20 and16 by turning back the chromaticity sextupoles.

Conclusions:

✍ The Au^{77+} bunched beam at <dR> =0 could survive without any chromaticity and tune corrections for the 300 ms flattop at $B\rho$ = 95.83 T-m (AGS proposed maximum $B\rho$) though it was very tight and no extraction bumps existed.

✍ We prefer the working point $Q_{h,v}$={~8.735, ~8775} to {~8.775, ~8.735} since it requires less current for the tune control quadrupoles. It should be noted that the NewFEB bumps will cause a tune shift ΔQ_h =~-0.02.

☞ For the next study, we propose

- while maintaining $Q_{h,v}$ ={8.735,8775}at <dR> =0 ,
- study chromaticity effects,
- study bump effects (using BLWF07 and/or BLWH20),

by measuring CT readings quantitatively, and taking more complete TM, IPM and WCM data.

References:

[1] BNL-48230, M. Tanaka and Y.Y. Lee, *The AGS-Booster Complex for the g-2 Experiment and RHIC Injection*.